Geophysical Research Abstracts
Vol. 12, EGU2010-11057-1, 2010
EGU General Assembly 2010

A measure for hydrological connectivity at the drainage basin scale

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Many previously glaciated basins have poorly defined and highly variable drainage networks. Whilst there is an understanding of runoff generation mechanisms at the hillslope scale, it is sometimes unclear how runoff accumulates to produce a basin scale response in such regions. As a result traditional hydrological models often fail to produce reliable and consistent results. It is commonly accepted that runoff response at the basin scale is determined by local scale runoff generation, the connectivity of runoff to the stream network, and the connectivity of the drainage network downstream. The fill and spill mechanism has shed light on how individual elements connect with each other but a quantitative description of connectivity at the drainage basin scale is missing. An improved means to measure the dynamics of drainage network connectivity at the catchment scale is needed to predict basin scale streamflow. In this investigation, quantitative patterns of the hydrological connectivity of a subarctic Precambrian shield drainage basin in northern Canada were observed through remote sensing and water balance field observations. Storage and storage thresholds for fill and spill discharge generation were estimated. To measure the basin scale hydrological connectivity, the drainage network was treated as a graph network with stream reaches being the edges that connect sub-basin nodes. Connectivity was measured according to the fraction of active relative to potential stream reaches as well as the size of active drainage network connected to the outlet. Patterns of hydrological connectivity were then related to contributing area and basin runoff ratio, peak flow, time of concentration and traditional measures of basin wetness. Improved understanding of causal factors for the variable streamflow response to runoff generation in this environment will serve as a first step towards improved streamflow prediction in formerly glaciated landscapes, especially in small ungauged basins.